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Evaluation of Ambient Air Quality at Nekede and Naze Dumpsites, Imo State, Southeast Nigeria

Okere J.K[1]*, Abu G.O[2], Azorji, J.N[3], Nwachukwu M.O[4], Iheagwam, K.S. [3], Igwe C.E[5], Nzenwa P.O[6]

[1]Department of Chemical Sciences, Hezekiah University, Umudi, Imo State Nigeria
[2]Department of Microbiology, University of Port Harcourt, Rivers State Nigeria
[3]Department of Biological Sciences, Hezekiah University Umudi, Imo State Nigeria
[4]Department of Biology, Federal University of Technology, Owerri, Imo State Nigeria
[5]Department of Animal and Environmental Biology, Imo State University Owerri, Imo State Nigeria

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Abstract

Environmental pollution is one potential consequence of the lack of proper management of municipal solid waste. The study was carried out to evaluate on-site air quality at Nekede and Naze dumpsites for dry and wet seasons. Samples were measured at six (6) sampling points within and around the field using a series of calibrated handheld air quality monitoring equipment. At each sampling point, nine (9) air quality parameters (particulate matter ($PM_{2.5}$ and PM_{10}) Hydrogen sulfide (H_2S), Ammonia (NH_3), Sulphur dioxide (SO_2), Methane (CH_4), Carbon dioxide (CO_2), Carbon monoxide (CO) and Nitrogen dioxide (NO_2) were measured. Results showed that $PM_{2.5}$ and PM_{10} were detected in all stations of both dumpsites in both seasons. The highest values for all parameters measured were at the dumpsites except for CO which increased as distance progressed off the dumpsite. The CO ranged from 0.42 to 0.94 ppm at Nekede dumpsite and 0.20-1.12 ppm at Naze dumpsite during the dry season with the lowest values measured at station NKAQ1 and NZAQ1 with corresponding values of 0.42 and 0.20 ppm. CH_4 was less than 0.01 ppm at NZAQ3 in both seasons under study. All parameters measured were higher in the Nekede area than Naze except for NH_3 which ranged from 0.01 to 0.15 ppm and 0.02-0.17 ppm respectively for both seasons. Generally, NKAQ3 and NZAQ3 which all served as control stations had the lowest concentration of all parameters measured but otherwise for CO. Results further revealed that all parameters except CO exceeded the concentration values stipulated by USEPA and WHO, implying serious health implications in the study area**. Consequently, the results call for** a proper waste management system to ameliorate air pollution in the study area.

Keywords: Air Quality, Pollution, Environment, Imo State.

1 Introduction

Unguarded disposal of municipal solid waste is a serious environmental concern in most developing nations such as Nigeria [1] Over the years, there has been an upsurge in the lack of proper waste management and disposal system in Imo State. This has been attributed to increasing population, rapid urbanization, industrialization, and lax environmental laws [2];[3]. The commonest waste disposal system in the state entails the collection and dumping out of the city boundaries in open excavated waste dumps [4] which creates a plethora of waste dumpsites in many parts of the city [5]. Sadly, inadequate funding leaves the government agencies saddled with the responsibility of disposing of these wastes with the option of catering for the transportation and subsequent disposal of these wastes to their designated dumpsites with huge and unattended waste streams [6]. These waste dumpsites have been reported as the major breeding sites for microorganisms and other disease vectors like rodents, which eventually puts the health of the inhabitants at risk [7-8] and a major agent of air pollution. Consequently, an attempt to reduce these piles of waste streams could result in their *in situ* burning, which emits toxic gases and suspended particulates that interfere with ambient air quality [7]. The offensive odor emanating from the unguarded burning of these wastes is a major source of air pollution with its accompanying health issues [9];[10];[11]. Atmospheric pollution is one of the most challenging environmental issues that has attracted much research attention in recent times [12]. It is a condition in which certain substances, which include gases (sulfur dioxide, nitrogen oxides, carbon monoxides, hydrocarbons, etc.), particulates (smoke, dust, fumes, aerosols, etc), radioactive materials, and others are present in high concentrations that could result in undesirable effects to man and the environment [13]. It can be a result of natural or anthropogenic activities in the environment, as such ambient air quality of any place is usually determined by the extent of pollution [14-15]. Air pollution is not a new phenomenon, yet it remains one of the world's greatest problems facing humanity, and the leading environmental cause of morbidity and mortality. Both developed and developing nations share this burden, though awareness and stricter laws in developed countries have contributed to a larger extent in protecting their environment. Despite the global attention towards air pollution, the impact is still being felt due to its severe long-term consequences. A compelling reason for controlling air pollutants, such as suspended particulate matter (SPM) and sulfur dioxide (SO_2) is their damaging effect on human health. Exposure to high levels of air pollution can cause a variety of adverse health outcomes. It increases the risk of respiratory infections, heart

Corresponding author: Okere J.K, Department of Chemical Sciences, Hezekiah University, Umudi, Imo State Nigeria, E-mail: keriso_b@yahoo.com

disease, and lung cancer. Both short- and long-term exposure to air pollutants has been associated with health impacts. Among the extreme air pollution-related effects include high blood pressure and cardiovascular problems. WHO identified SPM as the most sinister in terms of its effects on human health [16]. Air pollution is believed to kill more people worldwide than AIDS, malaria, breast cancer, or tuberculosis [16] Airborne particulate matter (PM) is especially detrimental to health [17] and has previously been estimated to cause between 3 and 7 million deaths every year, primarily by creating or worsening cardio-respiratory disease [18]. Previous studies have established that 80% of untimely mortality associated with air pollution results in heart disease and stroke, while 14% results in chronic obtrusive pulmonary disease or acute respiratory infections, and 6% results in lung cancer [19]. According to [20], ambient air quality has been further impacted by piles of unattended waste all over some cities for days and even weeks. These wastes are transformed biologically by microbes or chemically by burning thereby emitting toxic components to all forms of biota.

The air quality of a particular locality is a function of how the people live and breathe [3]. Air quality, like the weather, could change daily or even hourly, hence the need to make information regarding the air quality of an area available is imperative for air quality evaluation and forecast [9]. Evaluation of air quality is necessary to view its importance in determining the level of population exposure to atmospheric pollution, which may cause unpleasant health conditions depending on the type of pollutant [21]; its degree of occurrence, length of time, rate of exposure; and the toxic level of the air pollutants in question [22]. This has become imperative to carry out at intervals owing to the increase in population, industrialization, urbanization, and paucity of air quality reports in Imo State [14]. Although several research works have been carried out in assessing air quality in the State, there seems to be a paucity of information on full-scale monitoring considering the contribution of pollutants from dumpsite areas. It is against this background that this study was carried out to evaluate ambient air quality at selected municipal dumpsites in Imo state, Nigeria.

2 Materials and Methods

2.1 Sampling Sites

Two (2) municipal solid waste (MSW) dump locations, an operational and the other non-operational were chosen for the study. Georeferencing at each dumpsite sampling point during the data collection was achieved using handheld Garmin Global Positioning System (GPS) V, (model CZ 99052-20).

2.2 Sampling Procedures

The air quality and meteorological data acquisition activities were measured at six (6) sampling points (including the control points) within and around the field using a series of calibrated handheld air quality monitoring equipment. At each sampling point, nine (9) air quality parameters: particulate matter ($PM_{2.5}$ and PM_{10}) Hydrogen sulfide (H_2S), Ammonia (NH_3), Sulphur dioxide (SO_2), Methane (CH_4), Carbon dioxide (CO_2), Carbon monoxide (CO) and Nitrogen dioxide (NO_2), and four (4) meteorological parameters; wind velocity, temperature, wind direction, and relative humidity were measured. To determine the particulate matter, AEROCET 831, model 80865-1 V2.0.0 was used. AEROCET 831 which has an accuracy of ±10%, calculates a volume for each detected particle, then assigns a standard density for the conversion. The standard density value is augmented by the K-Factor setting to improve measurement accuracy. The monitor uses light scatter to measure individual particles instead of clouds like other monitors [3]. The particle information is then grouped into size ranges and converted to mass concentration over 4 minutes at a flow rate of 2.83 L/min, into measuring ranges of 0.5-0.3µm. Levels of H_2S, NH_3, CO, CO_2, SO_2, CH_4, and NO_2 were measured using Industrial Scientific Corporation ITX Multi-Gas monitors. Measurements were done by holding the sensor to a height of about 2 meters in the direction of the prevailing wind and readings were recorded at stability. Meteorological data of temperature, relative humidity, wind speed, and wind direction were measured using automated multiparameter handheld Kestrel 4200. The units of readings were adjusted. Its reading accuracy is ± 3%. To avoid inaccurate readings, especially for humidity, measurements were taken avoiding direct sunlight, which could heat the air inside the humidity sensor enclosure and cause wrong data. The Kestrel 4200 unit which simultaneously shows 3 current measurements was held into the wind at a height of about 2 meters. The study was done between 2015 and 2016, during the dry and rainy seasons respectively.

3 Results

The dry and rainy seasons' air quality results of Nekede and Naze dumpsites are displayed in Tables 1 and 2. $PM_{2.5}$and PM_{10} were detected in all stations of both dumpsites in both seasons. The highest values for all parameters measured were at the dumpsites except for CO which increased as distance progressed off the dumpsite. The CO ranged from 0.42 to 0.94 ppm at Nekede dumpsite and 0.20-1.12 ppm at Naze dumpsite during the dry season with the lowest values measured at station NKAQ1 and NZAQ1, with corresponding values of 0.42 and 0.20 ppm. CH_4 was less than 0.01 ppm at NZAQ3 in both seasons under study. All parameters measured were higher in the Nekede area than Naze except for NH_3 which ranged from 0.01 to 0.15 ppm and 0.02-0.17 ppm respectively for both seasons as depicted in figures 1 and 2. Generally, NKAQ3 and NZAQ3 which all served as control stations had the lowest concentration of all parameters measured but otherwise for CO. The relative humidity in the Nekede area ranged from 42.50 to 84.10% while in the Naze area, it spanned 45.96-83.80%.

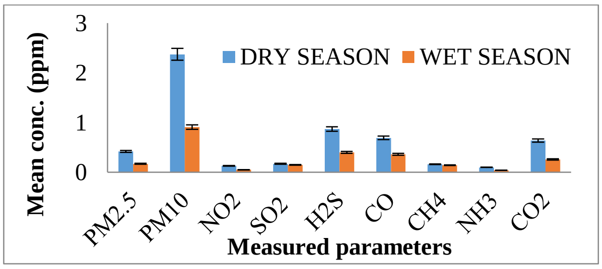

Figure 1: Mean seasonal concentration of air quality parameters at Nekede dumpsite

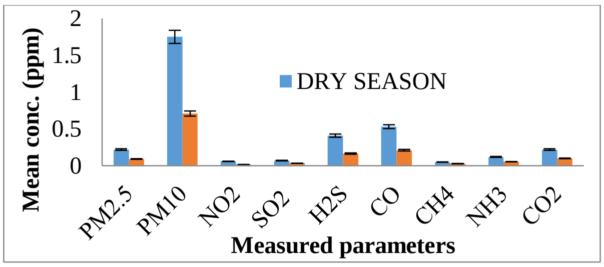

Figure 2: Mean seasonal concentration of air quality parameters at Naze dumpsite

Table 1: Dry season Air Quality results at Nekede and Naze dumpsite areas

	AIR QUALITY MONITORING AT NEKEDE AREA			AIR QUALITY MONITORING AT NAZE AREA		
SAMPLING ID:	NKAQ 1	NKAQ2	NKAQ 3	NZAQ 1	NZAQ 2	NZAQ 3
GPs :	N05.46527 E07.02983	N05.46549 E07.02989	N05.46304 E07.02871	N05.46848 E07.04152	N05.465896 E07.04138	N05.47168 E07.04167
$PM_{2.5}$(ppm)	0.66	0.43	0.19	0.29	0.33	0.05
PM_{10} (ppm)	3.91	2.12	1.09	1.83	2.11	1.31
NO_2 (ppm)	0.18	0.14	0.09	0.10	0.06	0.02
SO_2 (ppm)	0.21	0.16	0.07	0.12	0.05	0.04
H_2S (ppm)	1.37	0.79	0.46	0.60	0.35	0.30
CO (ppm)	0.42	0.71	0.94	0.20	0.29	1.12
CH_4 (ppm)	0.29	0.14	0.06	0.08	0.02	<0.01
NH_3 (ppm)	0.15	0.11	0.04	0.17	0.13	0.06
CO_2 (ppm)	0.88	0.67	0.39	0.37	0.21	0.09
Meteorological Parameters						
Wind Velocity (m/s)	0.70	0.90	1.20	1.20	1.00	1.80
Wind direction	SW	SW	SW	SW	SW	SW
Temperature °C	30.70	29.40	29.90	28.90	29.10	29.20
Relative Humidity (%)	65.70	78.50	42.50	56.40	69.50	45.96

Note: NKAQ1, NKAQ2, NKAQ3=Nekede air quality sample stations 1, 2, 3 respectively while, NZAQ1, NZAQ2, and NZAQ3 = Naze dumpsite air quality sample stations 1, 2, and 3 respectively.

Table 2: Rainy season Air Quality results at Nekede and Naze dumpsite areas

	AIR QUALITY MONITORING AT NEKEDE AREA			AIR QUALITY MONITORING AT NAZE AREA		
SAMPLING ID:	NKAQ 1	NKAQ2	NKAQ 3	NZAQ 1	NZAQ 2	NZAQ 3
GPs :	N05.46527 E07.02983	N05.46549 E07.02989	N05.46304 E07.02871	N05.46848 E07.04152	N05.465896 E07.04138	N05.471 68 E07.041 67
PM $_{2.5}$ (ppm)	0.28	0.18	0.07	0.11	0.15	0.02
PM_{10}(ppm)	1.38	0.94	0.43	0.76	0.80	0.58
NO_2 (ppm)	0.08	0.05	0.02	0.03	0.01	0.01
SO_2(ppm)	0.21	0.16	0.07	0.05	0.02	<0.01
H_2S (ppm)	0.62	0.40	0.19	0.27	0.14	0.09
CO(ppm)	0.19	0.32	0.43	0.07	0.13	0.44
CH_4(ppm)	0.13	0.06	0.02	0.05	0.01	<0.01
NH_3(ppm)	0.08	0.04	0.01	0.09	0.06	0.02
CO_2(ppm)	0.39	0.24	0.16	0.14	0.09	0.04
Meteorological Parameters						
Wind Velocity (m/s)	2.70	1.90	1.20	3.20	2.0	1.8
Wind direction	SW	SW	SW	SW	SW	SW
Temperature °C	27.80	27.40	26.90	27.30	28.10	26.90
Relative Humidity (%)	84.10	83.50	84.00	82.40	80.90	83.80

Note: NKAQ1, NKAQ2, NKAQ3=Nekede air quality sample stations 1, 2, 3 respectively while, NZAQ1, NZAQ2, and NZAQ3 = Naze dumpsite air quality sample stations 1, 2, and 3 respectively.

4 Discussion

Generally, the concentrations of the pollutants were observed to attenuate as distance increased away from the dumpsite. This decreased concentration of the air pollutants away from the dumpsite could be due to the impact of distance as well as temperature disparity on the concentration of pollutants off their regional origin [23]. There was an inconsistency in the values obtained for $PM_{2.5}$ and PM_{10} as distance increased away from the Naze dumpsite as compared to the Nekede dumpsite. While the control point of Naze (NZAQ3) was higher than the preceding station NZAQ2, the Nekede control station (NKAQ3) was lesser than the preceding station NKAQ2. The sawmill located about 250 meters from the Naze dumpsite could have enhanced the concentration of the particulate matter. The general higher level concentration of measured parameters during the dry season as compared with the rainy regime is consistent with study by [24-25]. In the study of ambient air quality of MSW dumpsite in a district in India by [24] about 50% lesser variation values for SO_2, NO_2, PM for the rainy season values as compared to the concentration in the dry season was observed. The high frequency of rainfall could clear up most air borne pollutants spawn and discharged from the parent source [25]. The dry season is generally a serene period in terms of air pollutants dispersal than the rainy regime, which enhances facilitation of further constancy to atmosphere and therefore sluggish dispersal of resultant pollutants occurs, entrapping or concentrating of most ambient air pollutants close to ground level [26-29]. Nevertheless, the swell of CO concentration of the dumpsite may be because of high vehicular traffic on the Nekede road which is about 300m from the waste dumpsite. [24] asserts the same, so emissions from the vehicles could raise the CO concentration level near the road. Thus with higher vehicular traffic around the Naze dumpsite, as two parallel roads exist (the Akachi road and the Aba road) as compared to just a road (Nekede) around the Nekede dumpsite, that could explain the higher increase in the CO around the Naze dumpsite as distance increased away from the dumpsite as against the Nekede dumpsite.

The higher level of PM_{10} ascertained at the dumpsite was due to waste degradation and aging [22]. The concentration levels for all parameters except for NH_3 were higher in both seasons at Nekede dumpsite. According to [30]; and [31] atmospheric NH_3 sources are animal waste, humus ammonification, including soil emissions, leaching from ammonia benched fertilizers, and emissions from the industries. It was observed that major agricultural activities going on around the Naze dumpsites with high application of ammonia-based fertilizers could be responsible for the higher concentration level of NH_3 than around the Nekede dumpsite. Values obtained in this study were lower than values obtained by [11], however, except for CO, other parameters' concentrations were above the permissible limit as prescribed by [32];[33]. The results of this study align with that of [34-35].

Meteorological factors such as temperature, wind speed, and relative humidity have an important impact on pollutant concentration. The increased temperature which has an indirect relationship with relative humidity [12] could have enhanced poor air quality as seen during the dry season, where the average temperature was higher than the rainy regime. Wind speed has been reported to have an inverse relationship with pollutants as could be seen in Tables 1 and 2. Wind speed is a key parameter that affects the dispersion of pollutants [36]. Hence with the poor wind speed in the area, pollutants accumulation could be aided. So, there is concern about the adverse impact of these resulting concentration levels of pollutants. A high level of NH_3 in the air could cause respiratory tract damage, impact the eyes as well as an increased corrosive impact on the mucous membrane [36]. SO_2 emission which is largely dependent on combustion and bacterial process [3], could have major health effects at high concentrations. [37] opines that SO_2 pollution seems to correlate with the effect of NH_3 as it could be eyes and ears irritant. Furthermore, it could enhance the rate of breathing and air starvation and suffocation, even as it has the potential to distort pulmonary functions. A topical Chinese study according to [38] and [36] established that high-level concentrations of NO_2, PM_{10}, and SO_2 could cause alteration of several physiological functions including hematopoietic function (reduced hemoglobin and white blood cell); heart function (increased heart rate and blood pressure); renal function (increased urine creatinine and urea); inflammatory response function (increase in C-reactive protein); liver function (increase in glutamic-pyruvic transaminase, serum albumin, and total bilirubin as well as metabolic endocrine function (high and low-density lipoprotein, cholesterol increase, and the ratio of low-density lipoprotein to high-density lipoprotein). Issues associated with $PM_{2.5}$ have also been documented. A study in China found out the probability of almost 10%, 4.5%, and 13.5% risk of death from ischaemic heart disease, an increase in the risk of mortality from hemorrhagic stroke, and an increase in the risk of mortality from ischaemic stroke respectively [13];[19] from $PM_{2.5}$. Methane, a constituent of landfill gas, capable of posing high explosion hazard between its lower explosive limit (LEL) of 5% and upper explosive limit (UEL) of 15% by volume, can displace oxygen in confined areas, causing an atmosphere devoid of oxygen (Rim-Rukeh, 2014). About 50% of landfill gas emitted is methane, 45% is CO_2 while the 5% constitute hydrogen, nitrogen, oxygen, and other trace gases [20]. The global warming potential (GWP) of methane is 21, over 100 years [22]. The implication is that on a kilogram-for-kilogram basis, over 100 years, methane is 21 times more potent than carbon dioxide in causing climate change [11]. It is considered an asphyxiant at tremendously high concentrations and can displace oxygen in the blood at a concentration of 1000 ppm.

Hydrogen sulfide (H_2S) which generates an extremely strong rotten-egg stench even at very small concentrations is the most regular sulfide accountable for odors in the landfill and the most emitted from landfills at the maximum rates and concentration, with humans extremely sensitive to the odor even at extremely low concentrations of 0.5-1 ppb [9]. The ambient H_2S concentration level is very high measuring about 0.09-1.37 ppm but at levels around 50 ppb, the odor could be offensive to humans (ATSDR, 1999) and could cause an explosion; the lower and upper explosive limit is 4%, and 44% respectively [16]. According to WHO, about 90% of the global populace suffers from poor ambient air quality and about 600,000 children die yearly due to poor air quality, which is about 9% of the total [18]. It causes respiratory diseases, with 27.5% of deaths due to lower respiratory tract infection such as asthma; cardiovascular diseases such as coronary artery calcium and common carotid artery intima-media thickness [23]; over 29 % of the burden of stroke was attributed to air pollution [39-40]. [40] documents that the estimated toll of pollution on the global economy as regards welfare losses are over US$ 5.1 trillion; and in the 15 countries with the highest greenhouse gas emissions, health impacts of air pollution are estimated to cost close to 5 percent of GDP; However smart climate change policies that reduces air pollution, could save over 1 million lives a year by 2050 and yield health benefits worth over US$54 trillion – about twice the costs of mitigation.

5 Conclusion

The present study appraised the seasonal variation of air quality at Nekede and Naze dumpsites concerning nine air pollutants. Results showed a significant level of $PM_{2.5}$ and PM_{10} were detected in all stations of both dumpsites in both seasons. Higher levels of PM were recorded during the dry season than during the rainy season. The highest values for all parameters measured were at the dumpsites except for CO which increased as distance progressed off the dumpsite. All parameters measured were higher in the Nekede area than Naze except for NH_3. The result of the study indicates poor air quality in the study area which implies atmospheric pollution due to elevated concentration of all the parameters measured. This calls for adequate attention and best environmental management practices to reduce the level of air quality deterioration in the study area.

Ethical issue

Authors are aware of and comply with, best practices in publication ethics specifically about authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests, and compliance with policies on research ethics. Authors adhere to publication requirements that the submitted work is original and has not been published elsewhere in any language. Also, all procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. All procedures performed in this study involving animals were following the ethical standards of the institution or practice at which the studies were conducted.

Competing interests

The authors declare that no conflict of interest would prejudice the impartiality of this scientific work.

Authors' contribution

All authors of this study have a complete contribution for data collection, data analyses, and manuscript writing.

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